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(71) Applicant (for all designated States except US): **EN-VENTURE GLOBAL TECHNOLOGY, LLC** [US/US];
16200 A Park Row, Houston, TX 77084 (US).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **SHUSTER, Mark** [US/US]; 19115 Prospect Ridge Lane, Houston, TX 77094 (US). **GRAY, Malcolm** [US/US]; 9025 Briar Forest, Houston, Texas 77024 (US). **GRINBERG, Grigoriy** [US/US]; 4758 Mount Airy, Sylvania, OH 43560 (US). **SHADE, Matt** [US/US]; 12831 Wendover Drive, Plymouth, MI 48170 (US). **PETLYUK, Alla** [US/US]; 933 Trellis Lane, West Chester, PA 19382 (US). **COSTA, Scott** [US/US]; 25614 Broadcrest Court, Katy, TX 77494 (US).

(74) Agents: **HAYNES AND BOONE LLP** et al.; 901 Main Street, Suite 3100, Haynes and Boone, LLP, Dallas, TX 75202 (US).

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Declaration under Rule 4.17:

— of inventorship (Rule 4.17(iv))

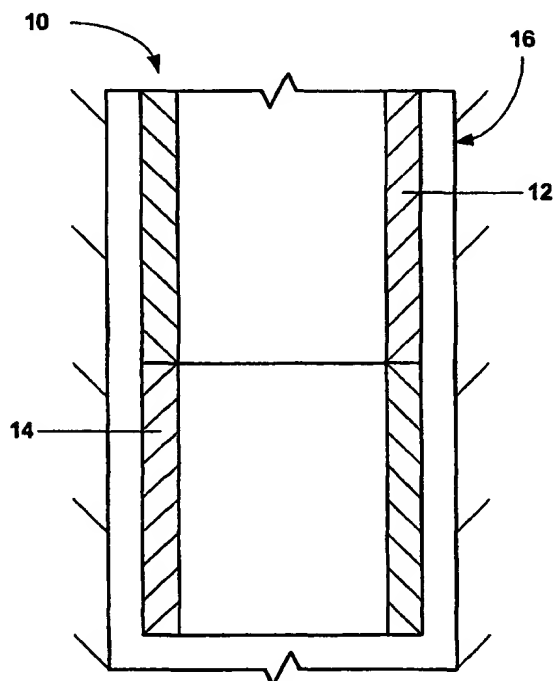
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— with international search report

— with amended claims

[Continued on next page]

(54) Title: EXPANDABLE TUBULAR



(57) Abstract: A system for reducing the coefficient of friction between an expansion device (20) and a tubular member (14).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

AMENDED CLAIMS

received by the International Bureau on 13 January 2006 (13.01.2006)

1-672. (Canceled)

673. (Original) An expandable tubular member, comprising:

a tubular body;

wherein a yield point of an inner tubular portion of the tubular body is less than a yield point of an outer tubular portion of the tubular body.

674. (Original) The expandable tubular member of claim 673, wherein the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body.

675-676. (Canceled)

677. (Original) The expandable tubular member of claim 673, wherein the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body.

678-679. (Canceled)

680. (Original) The expandable tubular member of claim 673,

wherein the yield point of the inner tubular portion of the tubular body varies as a function of the radial position within the tubular body; and

wherein the yield point of the outer tubular portion of the tubular body varies as a function of the radial position within the tubular body.

681-728. (Canceled)

729. (Original) A method of manufacturing an expandable tubular member, comprising:

providing a tubular member;

heat treating the tubular member; and

quenching the tubular member;

wherein following the quenching, the tubular member comprises a microstructure comprising a hard phase structure and a soft phase structure.

730-732. (Canceled)

733. (Original) The method of claim 729, wherein the provided tubular member comprises a microstructure comprising one or more of the following: martensite, pearlite, vanadium carbide, nickel carbide, or titanium carbide.

734. (Original) The method of claim 729, wherein the provided tubular member comprises a microstructure comprising one or more of the following: pearlite or pearlite striation.

735. (Original) The method of claim 729, wherein the provided tubular member comprises a microstructure comprising one or more of the following: grain pearlite, widmanstatten martensite, vanadium carbide, nickel carbide, or titanium carbide.

736-737. (Canceled)

738. (Original) The method of claim 729, wherein following the quenching, the tubular member comprises a microstructure comprising one or more of the following: ferrite, grain pearlite, or martensite.

739. (Original) The method of claim 729, wherein following the quenching, the tubular member comprises a microstructure comprising one or more of the following: ferrite, martensite, or bainite.

740. (Original) The method of claim 729, wherein following the quenching, the tubular member comprises a microstructure comprising one or more of the following: bainite, pearlite, or ferrite.

741-743. (Canceled)

744. (Currently Amended) A method of manufacturing an expandable tubular member, comprising:

- providing a tubular member;
- heat treating the tubular member;
- quenching the tubular member;
- positioning the quenched tubular member within a preexisting structure; and
- radially expanding and plastically deforming the tubular member within the

preexisting structure,
wherein following the quenching, the tubular member comprises a microstructure comprising a hard phase structure and a soft phase structure.

745-757. (Canceled)

758. (Original) A system for radially expanding and plastically deforming a tubular member, comprising:

an expansion device positioned in the tubular member; and
wherein the coefficient of friction between the expansion device and the tubular member during radial expansion and plastic deformation is less than 0.08.

759. (Canceled)

760. (Original) The system of claim 758, additionally comprising:
lubricant between the tubular member and the expansion device.

761-776. (Canceled)

777. (Original) The system of claim 758, additionally comprising:
a coating on the expansion device.

778. (Canceled)

779. (Original) The system of claim 758, additionally comprising:
a coating on the tubular member.

780-797. (Canceled)

798. (Original) The system of claim 758, wherein lubricant is injected through at least a portion of the expansion device between the tubular member and the expansion device when a predetermined pressure is met.

799. (Original) The system of claim 758, wherein lubricant is injected through at least two portions of the expansion device between the tubular member and the expansion device at two different pressures.

800. (Original) The system of claim 758, wherein the expansion device comprises:

- a tapered portion with an outer surface;
 - internal flow passage in the tapered portion; and
 - at least one circumferential groove having a first edge and a second edge having with a sliding angle on the outer surface of the tapered portion fluidically coupled to the internal flow passage for receiving lubricant during radial expansion and plastic deformation of the tubular member;
- wherein the sliding angle is less than or equal to 30 degrees.

801. (Original) The system of claim 758, wherein the expansion device comprises:

- a tapered portion with an outer surface;
 - internal flow passage in the tapered portion; and
 - at least one circumferential groove having a first edge and a second edge having with a sliding angle on the outer surface of the tapered portion fluidically coupled to the internal flow passage for receiving lubricant during radial expansion and plastic deformation of the tubular member;
- wherein the sliding angle is less than or equal to 10 degrees.

802. (Canceled)

803. (Original) The system of claim 758, wherein the expansion device comprises:

- a tapered portion having a tapered faceted polygonal outer expansion surface.

804. (Original) The system of claim 758, wherein the tubular member has a non-uniform wall thickness and the expansion device comprises:

- a tapered portion having a tapered faceted polygonal outer expansion surface.

805. (Original) The system of claim 758, wherein lubricant is stored in a reservoir with electrodes that are electrically coupled a capacitor in the expansion device and is injected through at least a portion of the expansion device between the tubular member and the expansion device when the capacitors discharges.

806-1232. (Canceled)

1233. (Original) A lubricant delivery assembly for radially expanding and plastically deforming a tubular member, comprising:

an expansion device having a tapered portion with an outer surface, at least one reservoir for housing a lubricant, at least one circumferential groove on the outer surface fluidically connected to the reservoir; and
a lubricant injection mechanism to force lubricant into the at least one circumferential groove while radially expanding and plastically deforming the tubular member when a predetermined lubricant pressure is reached.

1234. (Original) The lubricant delivery assembly of claim 1233, wherein lubricant is stored in a reservoir with a magnetic coil in the expansion device and is injected through at least a portion of the expansion device between the tubular member and the expansion device when current runs through the magnetic coil.

1235. (Original) The lubricant delivery assembly of claim 1233, wherein lubricant is stored in a reservoir in the lubrication device and injected through at least a portion of the expansion device between the tubular member and the expansion device when vaporized.

1235. (Original) The lubricant delivery assembly of claim 1233, wherein lubricant is stored in a reservoir with electrodes that are electrically coupled a capacitor in the expansion device and is injected through at least a portion of the expansion device between the tubular member and the expansion device when the capacitors discharges.

1236–1263. (Canceled)

1264. (Original) A system for radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member.

1265. (Original) The system of claim 1264, additionally comprising:
lubricant between the tubular member and the expansion device.

1266–1281. (Canceled)

1282. (Original) The system of claim 1264, additionally comprising:
a coating on the expansion device.

1283. (Canceled)

1284. (Currently Amended) A system for radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:

- an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member; and
- a coating on the tubular member.

1285–1301. (Canceled)

1302. (Original) The system of claim 1264, wherein lubricant is injected through at least a portion of the expansion device between the tubular member and the expansion device.

1303. (Currently Amended) A system for radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:

- an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member,
- wherein lubricant is injected through at least a portion of the expansion device between the tubular member and the expansion device when a predetermined lubricant pressure is met.

1303. (Currently Amended) A system for radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:

- an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member,
- wherein lubricant is injected through at least a portion of the expansion device between the tubular member and the expansion device when a predetermined lubricant pressure is met.

1304. (Currently Amended) A system for radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:

- an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior

surface of the tubular member,
wherein lubricant is injected through at least two portions of the expansion device
between the tubular member and the expansion device at two different
pressures.

1305. (Original) The system of claim 1264, wherein the expansion device comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 30 degrees.

1306. (Original) The system of claim 1264, wherein the expansion device comprises:
a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having
with a sliding angle on the outer surface of the tapered portion fluidically
coupled to the internal flow passage for receiving lubricant during radial
expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 10 degrees.

1307. (Canceled)

1308. (Currently Amended) A system for radially expanding and plastically deforming a
tubular member having a non-uniform wall thickness, comprising:
an expansion device having one or more expansion surfaces and a tapered portion
having a tapered faceted polygonal outer expansion surface in the interior
surface of the tubular member,
wherein lubricant is stored in a reservoir with electrodes that are electrically coupled
a capacitor in the expansion device and is injected through at least a portion
of the expansion device between the tubular member and the expansion
device when the capacitors discharges.

1309–1312. (Canceled)

1313. (Original) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member; and
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member.

1314. (Original) The method of claim 1313, additionally comprising:
injecting lubricant between the tubular member and the expansion device.

1315–1330. (Canceled)

1331. (Original) The method of claim 1313, additionally comprising
applying a coating on the expansion device prior to positioning within the tubular member.

1332. (Canceled)

1333. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member;
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and
applying a coating on the tubular member prior to positioning the expansion device within the tubular member.

1334–1346. (Canceled)

1347. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member; and
displacing the expansion device relative to the tubular member to radially expand and

plastically deform the tubular member,
wherein the expansion device comprises a processed finish.

1348. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member; and
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member,
wherein the expansion device has a relatively smooth surface roughness.

1349. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member; and
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member,
wherein the expansion device has a relatively smooth surface roughness and includes relatively evenly space oil pockets.

1350. (Canceled)

1351. (Original) The method of claim 1313, additionally comprising:
injecting lubricant through at least a portion of the expansion device between the tubular member and the expansion device.

1352. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:
positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member;
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and
injecting lubricant through at least a portion of the expansion device between the tubular member and the expansion device when a predetermined lubricant

pressure is met.

1353. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:

positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member;
displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member; and
injecting lubricant through at least two portions of the expansion device between the tubular member and the expansion device at two different pressures.

1354. (Original) The method of claim 1313, wherein the expansion device, comprises:

a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having with a sliding angle on the outer surface of the tapered portion fluidly coupled to the internal flow passage for receiving lubricant during radial expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 30 degrees.

1355. (Original) The method of claim 1313, wherein the expansion device, comprises:

a tapered portion with an outer surface;
internal flow passage in the tapered portion; and
at least one circumferential groove having a first edge and a second edge having with a sliding angle on the outer surface of the tapered portion fluidly coupled to the internal flow passage for receiving lubricant during radial expansion and plastic deformation of the tubular member;
wherein the sliding angle is less than or equal to 10 degrees.

1356. (Canceled)

1357. (Currently Amended) A method of radially expanding and plastically deforming a tubular member having a non-uniform wall thickness, comprising:

positioning an expansion device having one or more expansion surfaces and a tapered portion having a tapered faceted polygonal outer expansion surface in the interior surface of the tubular member; and

displacing the expansion device relative to the tubular member to radially expand and plastically deform the tubular member, wherein lubricant is stored in a reservoir with electrodes that are electrically coupled a capacitor in the expansion device; additionally comprising: charging the capacitor; discharging the capacitor through the electrodes; and injecting the lubricant through at least a portion of the expansion device between the tubular member and the expansion device when the capacitors discharges.

1358-1369. (Canceled)

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(72) Inventors; and

(75) Inventors/Applicants (for US only): SHUSTER, Mark
[US/US]; 19115 Prospect Ridge Lane, Houston, TX
77094 (US). GRAY, Malcolm [US/US]; 9025 Briar
Forest, Houston, TX 77024 (US). GRINBERG, Grigoriy
[US/US]; 4758 Mount Airy, Sylvania, OH 43560 (US).
COSTA, Scott [US/US]; 25614 Broadcast Court, Katy, TX
77494 (US). WASSON, Russel [US/US]; 5507 Oakhaven
Lane, Houston, TX 77091 (US). BRISCO, David, Paul
[US/US]; 405 Westridge Drive, Duncan, OK 73533 (US).
WATSON, Brock, Wayne [US/US]; 2535 Marsh Lane,
Number 1004, Carrollton, TX 75006 (US).

(74) Agents: MATTINGLY, Todd et al.; Haynes and Boone
L.L.P. 901 Main Street, Suite 3100, Dallas, TX 75202 (US).

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM,
TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM,
ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE,
SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
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ance Notes on Codes and Abbreviations" appearing at the begin-
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(54) Title: RADIAL EXPANSION SYSTEM

(57) Abstract: A radial expansion system.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/28831

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : E21B 23/00; C21D 9/08; G01N 17/00
US CL : 166/380, 382, 207, 242.1; 148/593; 73/87

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/380, 382, 207, 242.1; 148/593; 73/87

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,E	US 2005/0217768 A1 (ASHAHI et al) 06 October 2005 (06.10.2005), see the entire patent, in particular Paragraphs [0052]-[0078], [0090]-[0113], [0117], [0123]-[0137] and [0153]-[0154].	1-5, 8,9,11,12,21-50,123-126,135-141
Y,E		6,7,10,13-17,18-20
Y,E	US 2004/0149431 A1 (WYLIE et al) (05 August 2004) (05.08.2004), see figures 2 and 13A-13E.	6,7
Y	US 6,273,634 A (LOHBECK) 14 August 2001 (14.08.2001), see figures 2 and 3.	10,13-17
Y,E	US 6,662,876 A (LAURITZEN) 16 December 2003 (16.12.2003), see perforated or slotted tubular 420a.	18-20
X,E	US 2004/0194966 A1 (ZIMMERMAN) 07 October 2004 (07.10.2004), see "upper portion" 106 and "lower portion" of an expandable tubular member 104.	119-122,127-130

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

31 October 2005 (31.10.2005)

Date of mailing of the international search report

19 DEC 2005

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

Facsimile No. (703) 305-3230

Authorized officer

Hoang Dang

Telephone No. 703-308-2168

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US04/28831

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☒ Claims Nos.: 194-198
because they relate to subject matter not required to be searched by this Authority, namely:
the claims are directed to a mathematical expression.
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to
such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule
6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
Please See Continuation Sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all
searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite
payment of any additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report
covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is
restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐

The additional search fees were accompanied by the applicant's protest and, where applicable, the
payment of a protest fee.

☐

The additional search fees were accompanied by the applicant's protest but the applicable protest
fee was not paid within the time limit specified in the invitation.

☐

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US04/28831

BOX III. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim(s) 1-50, drawn to a method of forming a tubular liner within a preexisting structure.

Group II, claim(s) 119-122, drawn to an expandable tubular member.

Group III, claim(s) 123-126, drawn to an expandable tubular member..

Group IV, claim(s) 127-134, drawn to a method of radially expanding and plastically deforming a tubular assembly.

Group V, claim(s) 135-141, drawn to a method of manufacturing a tubular member.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

The special technical feature of the claims of Group I is a predetermined portion of the tubular assembly having a lower yield point than another portion thereof prior to the radial expansion and plastic deformation of the tubular assembly.

The special technical feature of the claims of Group II is the expandability coefficient of the expandable tubular member being greater than the expandability coefficient of another portion thereof.

The special technical feature of the claims of Group III is the tubular member having a higher ductility and a lower yield point prior to a radial expansion and plastic deformation than after the radial expansion and plastic deformation.

The special technical feature of the claims of Group IV is the use of less power to radially expand each unit length of the first tubular member than to radially expand each unit length of the second tubular member.

The special technical feature of the claims of Group V is the tubular member being processed after it has been positioned within a preexisting structure until it is characterized one or more final characteristics.

Inventions of Groups I-V lack unity because they do not rely on the same special technical feature as pointed out above